Once upon a time, hundreds of thousands of years ago, this comet was travelling in outer space, among the fixed stars, too far away to be attracted by the sun. What I mean by this outer starry space may be told by the help of the pictures I have shown you. In them the earth's distance from the sun is 10 inches, and the comet's longest range about 5 feet. Upon the scale of these figures only a few of the nearest fixed stars, perhaps two or three only, would be in the State of Connecticut. In this starry space the comet was travelling. What had happened before I do not try to guess. How, when, by what changes, its matter came together, and had become solid, I do not know, nor whether, in fact, it had not always been solid.

In the course of time its path and the sun's path through space lay alongside of each other, and the sun drew the comet down toward itself. If the comet had met no resistance as it ran around the sun, whether from the ether that fills space, or from the sun's atmosphere, and if it had not come near any of the planets, it would have gone off again into outer space whence it came. Some such cause robbed it of a little of its momentum, and it could not quite rise out of the sun's controlling force, but it came around again in an elliptic orbit to remain thenceforth a member of the solar system. It may or it may not then have been a great comet, like Donati's (in 1858).

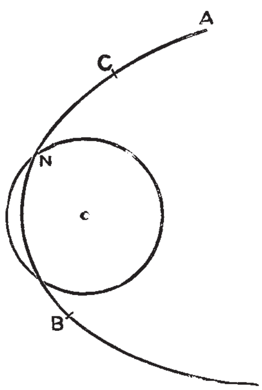

FIG. 14.

It was probably a small one. It may have made its circuit of the sun in tens of years or in tens of thousands.

At some time, probably in the early historic ages, it came near the huge planet Jupiter. When it had gone out of his reach it had just momentum enough left to go around the sun in its present orbit of $6\frac{2}{3}$ years. It went away from Jupiter an entire and single comet. As it came near the sun, his burning heat acting upon the cold rocky body of the comet cracked off and scattered in every direction small angular bits. At the same time a very thin vapour, shining by its own light, was set free. To this vapour both comet and sun had an unaccountable repulsion. It was driven off first by the comet every way. But soon that which was sent toward the sun was driven back again, and it went streaming off into space to form the comet's tail, a process ably set forth by Prof. Norton.

This matter which made the tail of the comet never got back. It had, moreover, nothing whatever to do with the meteoroid stream. The meteoroids are solid fragments. To them the sun, at least, had little repulsion. The comet was so small that perhaps the force with which a boy can throw a stone would have sent the bits of stone entirely off the comet, never to come back. Those which were shot forward from the comet near P (Fig. 1) went up along the orbit with greater velocity and rose higher from the sun than the comet did near D. Having a longer road to travel, they took a longer time to come around to P in each circuit. On the other hand, those bits which were shot backward followed the comet with less velocity and could not quite rise to D, and so having a shorter road to go over came sooner back to P, gaining on the comet at each circuit. Thus the stream grew longer slowly, and new fragments being thrown off at each circuit, the meteoroid stream grew in length to its hundreds of millions of miles. At times, the main comet has broken into two or more parts, giving us the double comets of 1845 and 1852, the Pogson comet of 1872, and the double meteor stream of November 1872.

THE NAVIGABLE BALLOON[1]

M. RENARD, captain of the Chalais-Meudon navigable balloon, has presented to the French Academy of Sciences a report of the experiments made with that balloon last year. Before starting on a fresh campaign in 1885, it was found necessary to make certain modifications in the construction of the balloon, affecting the ventilator, voltaic piles, commutators, &c. To measure the velocity of the balloon, an anemometer, the registrations of which would be too strong, seeing that the spiral is placed in front, was impracticable. There was no inconvenience, on the other hand, in the use of an aërial log. A balloon of gold-beater's skin, 120 litres in capacity, was accordingly filled in part with common gas, so as to keep exactly in equilibrium in the air. This balloon was attached to the central extremity of a bobbin of silk thread just 100 metres in length. The slightest effort is sufficient to unroll this bobbin when the central thread is drawn. The other extremity of the thread is wound round the finger of the operator. To obtain a measurement of speed the balloon is let go, when it quickly flies to the rear, and, on reaching the end of its line, conveys a perceptible indication of the fact in the finger holding the thread. The instant of its departure and that of the twitching sensation in the finger at its terminus are marked on a chronometer counting tenths of a second. Although the force transmitted to the small balloon during the unwinding of the thread is very slight, it is yet necessary to take account of it. Repeated trials in a closed place showed that the little balloon swerved 7 metres per minute, or 0·117 metre per second, under the influence of this light effort. If, then, t be taken as the time in seconds elapsing in the process of unwinding, the way traversed by the navigable balloon during the opera-

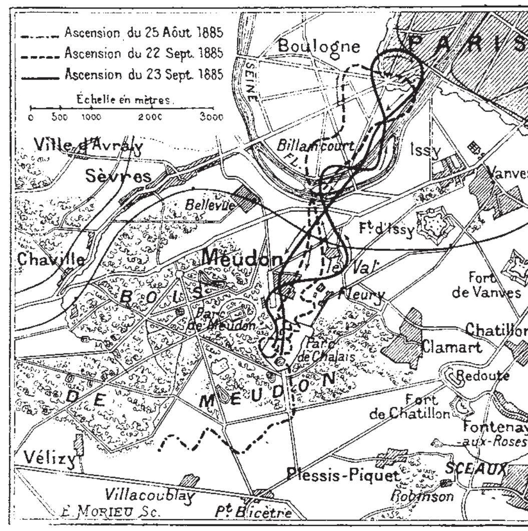

FIG. 1.—Map of the journeys of the *La France* balloon.

[1] From *La Nature*.

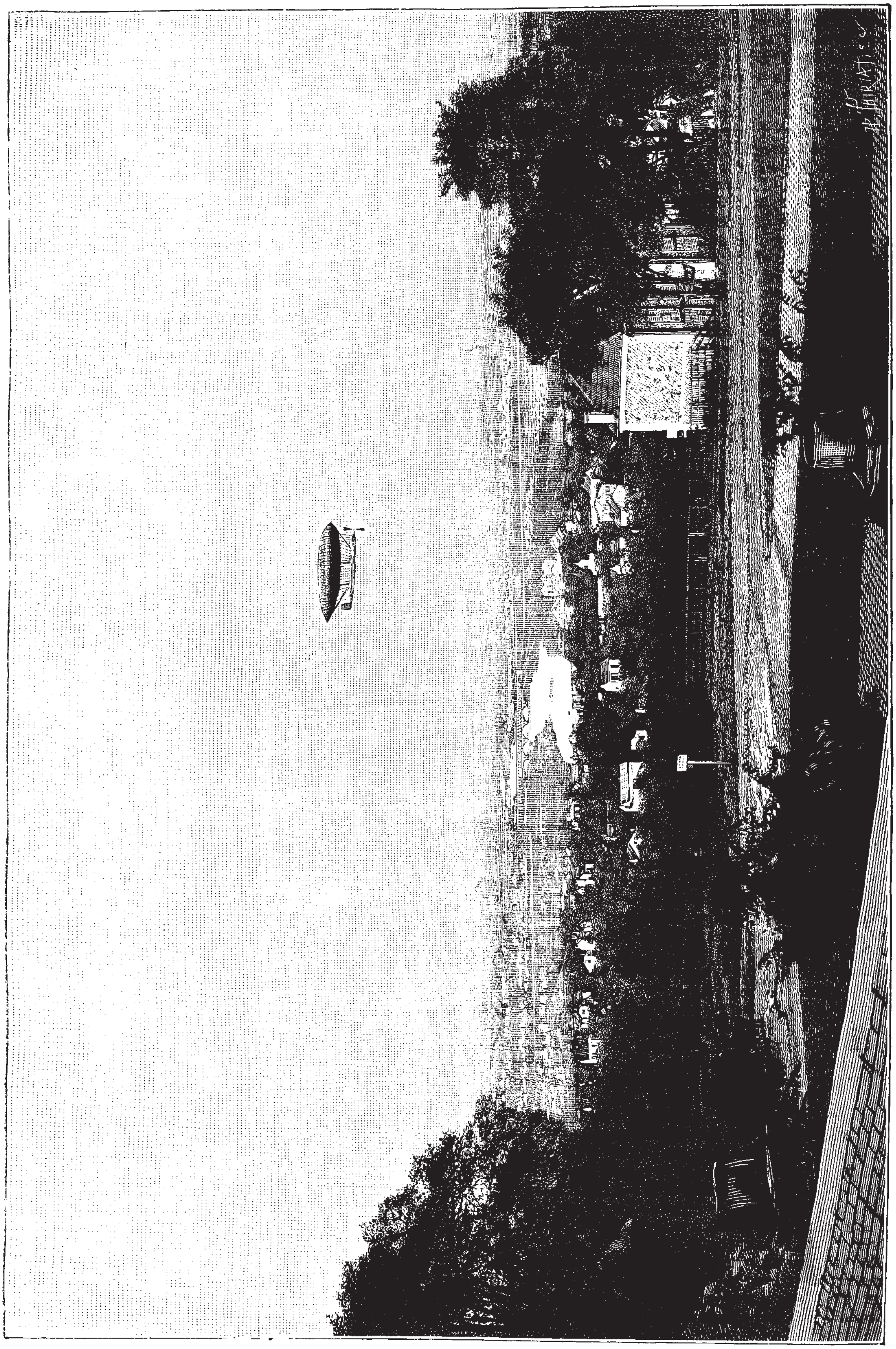

FIG. 2.—The *La France* above the Pont-du-Jour, Paris. Facsimile of an instantaneous photograph executed at the Observatory of Physical Astronomy, Meudon.

tion of unwinding will be $100 + 0{\cdot}117\,t$, and the speed of the balloon will be given by the formula—

$$S = \frac{100}{t} + 0{\cdot}117.$$

The preparations above referred to having been all completed, on the first fine day thereafter, August 25, the new mechanism was put on its trial, and behaved in a manner leaving nothing to be desired.

The balloon, which had been already filled for a certain time, having lost a considerable portion of its ascending force, M. Renard was under the necessity, on this occasion, of dispensing with the services of a third aëronaut, and mounted in the company solely of his brother, Capt. Paul Renard. The wind blew from the east. The speed measured at a low height by means of small balloons, appeared to be no more than 5 metres a second. Taking as a basis the approximate values of the preceding year, they calculated on obtaining a proper speed of nearly 7 metres per second, and were greatly surprised at being unable to gain the aërial current which prevailed at 250 metres above the valley of Chalais. The spiral, launched at fifty-five rounds per minute, proceeded with perfect regularity, yet they fell back—slowly, indeed, but continually. Desiring, nevertheless, to continue the experiment, and fearing to be carried away above the woods of the Chaville quarter, M. Renard turned the head of the balloon a little to the right, and soon, under the combined action of the wind and its own speed, it took a southern direction, and, the backward movement continuing, alighted after a voyage of 50 minutes close by the farm of Villa Coublay, whither he had directed it.

By reason of the bad weather the second definitive experiment did not come off till September 22, when the wind was blowing from the north-north-east—that is, from Paris, and its velocity in the lower strata varied from 3 to 3·50 metres per second. This time the aëronauts had their full complement of three: Capt. Renard at the helm and the motory machine, Capt. Paul Renard taking measurements and various observations, and, in addition, M. Duté-Poitevin. They started at 4.25 p.m. in a moist and foggy atmosphere. The spiral was set in motion and the head directed towards Paris. Though at first inclined to yaw, the course of the balloon soon righted itself, and, crossing the railway line above the station at 4.55, the balloon reached the Seine towards the western extremity of the island of Billancourt at 5 o'clock. Here, a measurement being taken, the progress of the balloon was found to be precisely 6 metres per second (time of unwinding = 17″, whence

$$S = \frac{100}{17} + 0{\cdot}117 = 5{\cdot}882 + 0{\cdot}117 = 5{\cdot}999\text{ m }).$$

At 5.12 p.m., after an excursion of 47 minutes, the balloon entered the enceinte by the bastion 65. It was only the increasing damp and fog which induced the aëronauts to cut short their voyage and make for home. The turning of the balloon was easily effected, and, aided this time by the aërial current, it approached its point of departure, which was entirely concealed by the fog, with surprising rapidity, retracing in 11 minutes the road it had taken 47 minutes to cover in going. The aërostat tacked about at first to keep its head to the wind, and in 10 minutes the little skiff touched the sward, whence it had ascended. During this voyage the balloon mounted to only 400 metres above the ground.

The next day before Gen. Campenon, Minister of War, and Gen. Bressonnet, President of the Committee of Fortifications, the balloon, *La France*, performed a fresh ascent with a success equal to that of the previous day. The itinerary of this voyage was much the same as that of the 22nd. The wind was weaker and bore the balloon to Paris. The time of the passage was 17 minutes going, 20 returning. The landing was very easy, and the balloon returned to the precise spot of its departure. The voyage could not be further prolonged for lack of ballast, the previous ascent having cost the balloon a partial loss of its ascending force.

On the valid basis of the experiments above described, M. Renard lays down some fundamental formulæ for calculating the resistance of balloons of construction analogous to that of *La France* with network and car.

Let R be the resistance in kilogrammes of the balloon *La France*, moving by the point; S, its speed per second in metres; θ, the work of direct traction (motory work in kilogrammetres); T, the work of the propelling screw shaft (in kilogrammetres); T', the work at the limits of the motive power in kilogrammetres); then

$$(1)\quad \left\{\begin{aligned} R &= 1{\cdot}189\,S^2. \\ \theta &= 1{\cdot}189\,S^2. \\ T &= 2{\cdot}300\,S^3. \\ T' &= 2{\cdot}800\,S^3. \end{aligned}\right.$$

At the rate of 10 metres, which would suffice for having the direction in most cases, we get

$$\begin{aligned} R &= 118{\cdot}9 \text{ kilogrammes.} \\ \theta &= 1189 \text{ kilogrammetres.} \\ T &= 2300 \text{ kilogrammetres, or 31 horse-power.} \\ T' &= 2800 \text{ kilogrammetres.} \end{aligned}$$

In general for a balloon of D diameter (in metres) we would get

$$\begin{aligned} R &= 0{\cdot}01685\,D^2\,S^2. \\ \theta &= 0{\cdot}01685\,D^2\,S^3. \\ T &= 0{\cdot}0326\,D^2\,S^3. \\ T' &= 0{\cdot}0397\,D^2\,S^3. \end{aligned}$$

It may be added that out of seven voyages, from August 9, 1884, to September 23, 1885, the aërostat has in five returned to its point of departure.

NOTES

WITH much regret we announce the death of the eminent Belgian botanist, Prof. C. J. E. Morren, of Liége, at the early age of fifty-three years.

AT a meeting of the Managers of the Royal Institution, held on Monday, March 1, the Actonian Prize of one hundred guineas was awarded to Prof. G. G. Stokes, P.R.S., for his lectures on Light, in conformity with the Acton Endowment Trust Deed. The following alteration has been made in the lecture arrangements before Easter:—Prof. Dewar, F.R.S., will begin a course of four lectures on Electro-Chemistry, on March 25, in place of Prof. Tyndall, F.R.S., on Light.

DR. JULIUS VON HAAST, C.M.G., F.R.S., the eminent geologist and Director of the Canterbury Museum, New Zealand, who is charged as Commissioner with the exhibits from that colony for the Colonial and Indian Exhibition, has arrived in London, and is busily at work in carrying out all the preliminary arrangements of the extensive court allotted to New Zealand. Dr. von Haast has been exceedingly successful in his journeys through the colony in obtaining large and valuable collections illustrating the fauna, flora, and geology, as well as collections of the art and industry of the Maori tribes. The food and other fishes, the birds, the timbers, as well as other native products and local industries will be well represented.

M. PASTEUR, at the last sitting of the Paris Academy of Sciences, stated that out of 325 cases of inoculation for hydrophobia, only one had failed—namely, that of the youth Pelletier, who came too long after being bitten, and under very unfavourable conditions. He advocated the establishment of an international hospital, to which patients would come from all parts of the world; and he suggested a discussion as to the locality and the fund for its support. At the close of the meeting Prof. Pasteur announced that he should next investigate whether diphtheria could not be treated by a similar process to that which he had found so successful against hydrophobia.